

CLAIMS

- 1 1. A system configured to allow an intermediate node to be gracefully removed from
2 service in a network, the system comprising:
3 a processing element of the intermediate node;
4 an operating system executed by the processing element to functionally organize
5 the intermediate node and invoke operations in support of a routing protocol executing on
6 the node; and
7 a Graceful Shutdown Notification message created by the processing element and
8 sent to routing protocol peers to announce an intention of the intermediate node to be
9 gracefully removed from service, the Graceful Shutdown Notification message further
10 indicating that the intermediate node is able to continue forwarding packets over the net-
11 work for a grace period, thereby allowing backup paths to be propagated to each peer and
12 put into service prior to a final withdrawal of routes advertised by the intermediate node.
- 1 2. The system of Claim 1 wherein the Graceful Shutdown Notification message com-
2 prises a Cease error code with one of an Administrative Graceful Shutdown and Admin-
3 istrative Graceful Reset subcode.
- 1 3. The system of Claim 2 wherein the Graceful Shutdown Notification message further
2 comprises a retention time value representing the grace period during which the interme-
3 diate node maintains a forwarding state after sending the Graceful Shutdown Notification
4 message.
- 1 4. The system of Claim 4 wherein the routing protocol is a Border Gateway Protocol
2 (BGP).
- 1 5. The system of Claim 5 wherein the intermediate node is a BGP router.

1 6. A method for allowing a router to be gracefully removed from service in a network,
2 the method comprising the steps of:

3 modifying a routing protocol executing on the router to enable the router to an-
4 nounce to its peers in the network its intention to be gracefully removed from service;
5 and

6 forwarding packets from the router over the network for a grace period, thereby
7 allowing backup paths to be propagated to each peer and put into service prior to a final
8 withdrawal of routes advertised by the router.

1 7. The method of Claim 6 wherein the routing protocol is the Border Gateway Protocol
2 (BGP) and wherein the step of modifying comprises the step of inserting one of an Ad-
3 ministrative Graceful Router Shutdown and Administrative Graceful Router Reset sub-
4 code into a BGP Graceful Shutdown Notification message with error code Cease.

1 8. The method of Claim 7 further comprising the step of setting a forwarding information
2 base (FIB) retention time value in a data field of the message, the FIB retention time
3 value representing the grace period during which the router maintains its forwarding state
4 after sending the Graceful Shutdown Notification message.

1 9. The method of Claim 8 further comprising the steps of:

2 sending the Graceful Shutdown Notification message from the router to its peers;
3 and

4 terminating all connections between the router and the peers, thereby implicitly
5 withdrawing from service, at the router, all original routes advertised on the terminated
6 connections.

1 10. The method of Claim 9 further comprising the steps of:

2 receiving the Graceful Shutdown Notification message at the peers; and

3 retaining the withdrawn routes advertised on the terminated connections at the
4 peers until one of selection of another route as a best path and elapse of the grace period.

1 11. The method of Claim 10 further comprising the step of, in response to one of selec-
2 tion of the best path and elapse of the grace period, removing the retained routes from
3 service.

1 12. The method of Claim 11 wherein the step of removing comprises the step of remov-
2 ing the retained routes from a FIB of each peer.

1 13. The method of Claim 11 further comprising the steps of, if a peer holds a backup
2 route for any of the withdrawn routes:
3 selecting the backup route as the best path; and
4 advertising the selected best path over the network.

1 14. The method of Claim 10 further comprising the steps of:
2 marking the original routes as last resort routes; and
3 triggering the network to announce backup routes and re-converge without fully
4 withdrawing the original routes.

1 15. Apparatus adapted to allow a router to be gracefully removed from service in a net-
2 work, the apparatus comprising:
3 means for modifying a routing protocol executing on the router to enable the
4 router to announce to its peers in the network its intention to be gracefully removed from
5 service; and
6 means for forwarding packets from the router over the network for a grace period,
7 thereby allowing backup paths to be propagated to each peer and put into service prior to
8 a final withdrawal of routes advertised by the router.

1 16. The apparatus of Claim 15 wherein the routing protocol is the Border Gateway Pro-
2 tocol (BGP) and wherein the means for modifying comprises means for inserting one of

3 an Administrative Graceful Router Shutdown and Administrative Graceful Router Reset
4 subcode into a BGP Graceful Shutdown Notification message with error code Cease.

1 17. The apparatus of Claim 16 further comprising means for setting a forwarding infor-
2 mation base (FIB) retention time value in a data field of the message, the FIB retention
3 time value representing the grace period during which the router maintains its forwarding
4 state after sending the Graceful Shutdown Notification message.

1 18. A computer readable medium containing executable program instructions for allow-
2 ing a router to be gracefully removed from service in a network, the executable program
3 instructions comprising program instructions for:

4 modifying a routing protocol executing on the router to enable the router to an-
5 nounce to its peers in the network its intention to be gracefully removed from service;
6 and

7 forwarding packets from the router over the network for a grace period, thereby
8 allowing backup paths to be propagated to each peer and put into service prior to a final
9 withdrawal of routes advertised by the router.

1 19. The computer readable medium of Claim 18 wherein the routing protocol is the Bor-
2 der Gateway Protocol (BGP) and wherein the program instruction for modifying com-
3 prises one or more program instructions for inserting one of an Administrative Graceful
4 Router Shutdown and Administrative Graceful Router Reset subcode into a BGP Grace-
5 ful Shutdown Notification message with error code Cease.

1 20. The computer readable medium of Claim 19 further comprising one or more program
2 instructions for setting a forwarding information base (FIB) retention time value in a data
3 field of the message, the FIB retention time value representing the grace period during
4 which the router maintains its forwarding state after sending the Graceful Shutdown Noti-
5 fication message.